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by
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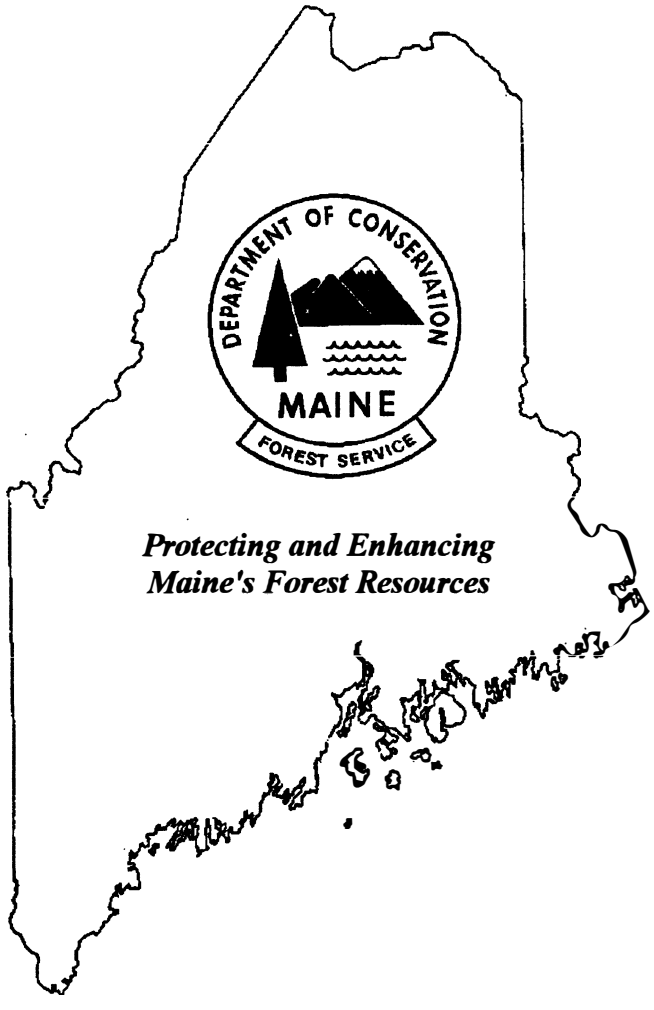

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Augusta, Maine

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Introduction

The browntail moth, *Euproctis chrysorrhoea* (L.), was accidentally brought to North America on European plant stock in the 1890's. It spread rapidly from its original beachhead in eastern Massachusetts along the eastern coast from Rhode Island into the Canadian Maritime provinces reaching a maximum range around 1916. The population subsequently went through a decline leaving only vestigial populations in coastal regions of Maine and Massachusetts by the 1960's. The Maine population of this pest began to expand again in the late 1980's and has now (1994) spread to several inhabited islands within Casco Bay. Larvae of this insect feed on a wide range of deciduous trees and shrubs. In addition to the larval defoliation, urticating hairs associated with all stages cause a severe rash upon contact with the skin. This brings the browntail moth in direct conflict with human activities within infested areas.

The Insect

Browntail moths are white with a conspicuous tuft of brown hair at the tip of the abdomen. Adults are present from July through August with oviposition occurring primarily in August. Browntail moth larvae hatch in August and feed under a loose web of silk on the upper surface of the host leaves before spinning their overwintering web. This late season feeding may cause a rusty appearance to the foliage but probably is of little consequence to the host. The browntail overwinters as second, third or fourth instar larvae within tightly bound silk webs. These webs range in length from 2 to 6 inches and are located on the terminal end of a host's branch; each web contains 100-400 larvae. Spring feeding begins very early (April in Maine) as the buds of host trees and shrubs are breaking through the bud scales. Some twig and shoot dieback can occur when browntail feeding precedes budbreak. Larvae feed close to their overwintering web until all of the nearby foliage is consumed and then they move in search of more food. Larvae from a umber of overwintering webs join to form communal webs at this stage. Communal webs are loosely formed and may be in excess of a foot in length with silk strands going in many directions as the larvae travel in and out in search of food. These communal webs are located in the crotches of branches as opposed to the terminal location of the overwintering webs. Feeding accelerates as the larvae grow and defoliation can be heavy by the end of May. Pupation starts in late June and is complete by the second week of July in most years.

The Problem

Populations of the browntail moth had reached such high levels on some of the Casco Bay islands by 1990 that the threat to residents' health and comfort was of increasing concern. In response to this threat, the Maine Forest Service and the City of Portland began to explore control alternatives. Developing alternatives was difficult due some unusual conditions. A major obstacle was the insects' proximity to the ocean and the need to keep any chemicals away from the water. Also many of the browntail webs were located high in the oak canopy eliminating hand clipping as a primary control measure as had been done in the past. Ground application of insecticide had drawbacks; poor access for equipment, limited water sources, and the need to use more carrier with the pesticide than is required for an aerial application. The need to use a larger volume of pesticide would increase the risk of drift or runoff. As a result of these considerations, aerial application was the delivery method of choice and pesticides were carefully chosen considering the environmentally sensitive nature of the infested area.

At the request of seasonal residents of Little Diamond Island, the Maine Forest Service, the City of Portland and NOVO Nordisk Bioindustrials, Inc. undertook a project in 1992 and 1993 to develop an efficacious method of applying the bacterial insecticide *Bacillus thuringiensis* (B.t.) for control of the browntail moth. This report presents the results of double applications of Foray 48B in the spring using fixed wing aircraft and helicopters. Also included are results of a single helicopter application of Foray 48B against the late season larvae.

Methods

Bacillus thuringiensis had been shown to be effective against browntail moth in laboratory tests but had not been used successfully in any aerial projects (McLane, et al).[1] The B.t. formulation Foray 48B was selected for use because it was already registered for browntail moth control and had proven efficacious in the field against a closely related species, the gypsy moth.

Three tests were conducted over a two year period with two tests run in the spring. The two spring tests targeted larvae that had overwintered and were beginning to feed on newly expanding foliage. *Bacillus thuringiensis* was applied in double treatments spaced one week apart, weather permitting. The late summer test involved a single application targeting newly emerged first instar larvae.

The late season test was very attractive for a number of reasons:

1. The early instars found late in the season should be highly susceptible to the B.t.
2. There is adequate foliage present at this time of year to serve as a target for the spray. (Spring applications are sometimes delayed because there is insufficient foliage present for the spray to be deposited on.)
3. Weather patterns are more stable than in the spring.

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[1] McLane, W.H., J.A.Finney and C.P.Schwalbe. 1978. Field evaluation of aerially applied *Bacillus thuringiensis* (Berliner) against the browntail moth, *Nygmia phaeorrhoea* (Donov). USDA-APHIS 81-30. 7pp.

4. Aerial applicators are more readily available at this time of year than in the spring.

Application parameters and weather conditions are summarized in Tables 1 and 2.

The Foray 48B trials conducted in 1992 and 1993 against the browntail moth larvae were run on Little Diamond Island, (Portland). This is a heavily forested island of approximately 65 acres located in Casco Bay. Red oak, which is a favored host for the browntail, is the predominant forest tree species. Browntail moth webs were observed over the entire island in each year of testing and were particularly abundant on the uppermost twigs of the red oak. The entire island was treated to minimize exposure of residents to the poisonous hairs. Untreated control areas were monitored on nearby Great Diamond Island which is similar in cover type but had lower population levels of the browntail moth.

Overwintering webs were sampled both low (0-6 ft.) on shrubs and high (25-30 ft.) on red oaks to reduce any variation in efficacy that might occur as a result of lack of penetration of the material through the canopy. Webs on low shrubs were selected prior to treatment and individually tagged after being checked to ensure they contained live larvae. Due to the great variation in the number of individuals within any given web, the webs were simply recorded as 'live' or 'dead'. Tagged webs, along with webs clipped from higher in the oak crowns, were to be examined after treatment to determine if they contained living or dead larvae. Webs were sampled seven and fourteen days after the final application to assess the efficacy of the insecticide. In June 1992, webs were also clipped from the very uppermost tips of the red oaks by a tree climber to determine the health of the larvae at the top of the canopy.

In the spring of 1992 Foray 48B was applied using a Bell G5 helicopter in a double application spaced the prescribed seven days apart. Trial applications were scheduled for late May and early June. This timing targeted early instar larvae and red oak leaves that were roughly three inches in length ensuring a good target for the B.t. Poor flying weather and equipment problems, however, delayed the first B.t. application and the larvae had developed to the third and fourth instar and had caused a substantial amount of feeding damage prior to treatment.

The late season trial was a new approach to browntail moth control and not much information was available on browntail moth habits at this time of year. The amount and duration of fall feeding needed to be established as did the level of protection from spray that the silking would provide. Larval development was monitored biweekly beginning August 6, 1992. Moths were abundant at that time but very few egg masses were seen. By August 24th egg masses were very abundant and 50% of those examined had first instar larvae resting on them. Some of the earliest hatching larvae had begun to spin loose webbing on the upper surface of the host leaves and were feeding under this material. A single Foray 48B application was applied on September 12, 1992 to control first and second instar larvae. A Bell G5 helicopter equipped as in the spring 1992 test was used.

Testing of a double application of Foray 48B was repeated in May of 1993 using fixed wing aircraft equipped with Micronair rotary atomizers. Foray 48b was applied undiluted in this trial. Larvae were predominantly in the second and third instars at the time of the first application and less than 20% were fourth instars at the time of the second application. Red oak buds were just

beginning to open but the larvae were actively mining them three days prior to the first application and defoliation was heavy on early flushing trees. The original design was to treat half of the island with a single application and half with a double application. Checks made after the first treatment showed very low levels of control and heavy defoliation so the entire island was treated with two applications.

Table 1. A Summary of Foray 48B Application Methods Used on Little Diamond Island for Controlling Browntail Moth, *Euproctis chrysorrhoea.*

Date	Rate		Diluant	Applications	Aircraft wing type	Nozzle number & type
	B.t. / Acre	Spray/ Acre				
June 3, 1992	30 B.I.U.	1 gallon	water	1st of 2	rotary	24 flat fan 8003
June 10, 1992	30 B.I.U.	1 gallon	water	2nd of 2	rotary	24 flat fan 8003
Sept.12, 1992	30 B.I.U.	3 gallon	water	1	rotary	24 flat fan 8003
May 10, 1993	24 B.I.U.	0.5 gallon	none	1st of 2	fixed wing	8 Micro AU 5000
May 23, 1993	24 B.I.U.	0.5 gallon	none	2nd of 2	fixed wing	8 Micro AU 3000

- no data collected

Table 2. Weather Conditions for Foray 48B Applications on Little Diamond Island for Controlling Browntail Moth.

Date	Time of Spray	Wind		Air Temperature (°F)		Rainfall (in.)
		Speed (mph)	Direction	Spray Time	Daytime	
June 3, 1992	7:00-7:30 a.m.	6-7	N	40	72	0 for 72h.
June 10, 1992	-	light	W	-	70's	0 for 24h.
Sept.12, 1992	7:00-7:30 a.m.	6-7	N	40	70's	0 for 72h.
May 10, 1993	6:12-6:30 a.m.	8	NE	40's	55	<0.1
May 23, 1993	6:25-6:50 a.m.	8	W	45	-	0 for 24h.

Results

Both spring applications of the 1992 trial were done in June, the first application taking place 7 to 10 days later than intended. The delay of the application allowed heavy defoliation (80 -90 %) to occur on some trees within the spray block prior to the treatment and allowed the larvae to develop and molt to the third and fourth instars. Defoliation was quite severe in 1992 because favorable weather conditions early in May allowed the high numbers of browntail larvae to cause extensive damage while the host was still in the bud stage. One week after the first application field checks revealed larvae still predominantly in the fourth instar with some larvae having molted to the fifth instar. Larval mortality resulting from the first application was low and, although most larvae appeared sluggish, no additional mortality was noted 7 or 14 days after the second application. Residents reported some relief from the pest but the trees within the spray

block were completely defoliated by the browntail moth. Comparison of the treated versus untreated areas by examination of webs had to be dropped in 1992 because the larvae left the overwintering webs to enter communal webs before any lethal effects of the spray could be observed. Communal webs may contain larvae some or all of the larvae from several overwintering webs making comparison of post to pre spray webs invalid. While limited population reduction appeared to take place, the level of defoliation and number of dermatitis reports from the island showed the level of control achieved during this trial was clearly unacceptable.

The second B.t. trial run in the fall of 1992 did not achieve the desired results either. The first post-spray observations were made 11 days after treatment and all the previously marked webs were tightly silked and contained numerous healthy larvae. A tree climber was employed to collect additional webs from the topmost branches of the mature red oaks. Eleven webs were examined and found to contain healthy larvae and were tightly bound with silk, well prepared to enter the winter. The day of the field checks was warm and dry, providing favorable conditions for the browntail to feed and a high number of webs had larvae emerging from them to actively feed under cover of a loose layer of silk. No larvae were seen moving or feeding outside this limited area adjacent to the web. Random checks over the entire island revealed active larvae in all webs checked. It was noted that the stage of construction of webs was highly variable reflecting the extended hatching period of the eggs. The trial was considered a failure against the browntail. This fact was reaffirmed the following spring by the high population levels within the treated areas. The fall webworm, *Hyphantria cunea*, was abundant on the island and several nests were observed in close proximity (within 25 feet) to the browntail webs. All the nests of the fall webworm which were examined (five) contained dead or sluggish fall webworm larvae in them while similar fall webworm nests on Great Diamond Island contained healthy larvae. This may suggest some tolerance of the browntail to the material rather than a lack of deposit on the target.

The 1993 spring trial was applied three weeks earlier than the previous year's trial in an effort to ensure treatment of larvae predominately in the second instar. Unfortunately, the temperature did not rise following the B.t. application. This severely limited any feeding by the insect resulting in very low mortality from the first B.t. application. Rain and wind persisted in some combination delaying the second application by a week but the larvae were still predominantly in the third instar at spray time. The overwintering webs that were checked prior to treatment were again vacated by the larvae before post spray counts could be taken. These larvae had relocated to undefoliated parts of the host and had formed large communal webs after defoliating the area surrounding the overwintering web. This activity nullified use of the pre- vs. post spray field checks for assessing the B.t. efficacy in this trial. Field observations indicated that large numbers of larvae were sick and dying within the spray block while few larvae were found in this condition in the untreated control sites. However, defoliation was nearly 100% throughout the area and high numbers of the larvae pupated. This trial failed to provide foliage protection or limit the interface between residents and the insect.

Discussion

Aerial applications of Foray 48B in either the spring or late season failed to attain acceptable levels of control of the browntail moth population. The ultimate goal of a project against this pest is to minimize the exposure of the residents to the urticating hairs found on the larvae. A very high level of population control must be reached to accomplish this goal.

McLane, et al (1978) attained levels of mortality in excess of 95 % in laboratory tests of the effectiveness of B.t. against browntail using 8 BIU dosages. These results did not translate to the field trials on Little Diamond Island. In these field trials, different control strategies were tried but the right combination of equipment, insect, substrate and weather conditions was never achieved. Flat fan nozzles and rotary atomizers (Micronairs) were utilized in different years to ensure the uniformity of coverage over the spray blocks. Timing of application was varied to address the early spring development of this insect. All application rates used in the trials were at or near the maximum registered levels. Field observations throughout these trials revealed some mortality even in later instar larvae but the number of human dermatitis cases and the plant host defoliation were both too high to be acceptable. Weather conditions, especially in the spring, account for much of the poor performance of the insecticide. Given the field performance to date no further aerial trials of B.t. products are planned.

The browntail is very well adapted for survival in rigorous environments making it a difficult target for control efforts. Browntails overwinter predominantly as second and third instar larvae. Their advanced spring development allows them to feed on developing buds well ahead of the buildup of tannins and other plant defenses. Elevated temperatures within the microclimate of the feeding site adjacent to the webs allow the larvae to feed during sunny periods in late April when the ambient temperatures may be less than 40° F. The larvae may feed for very short periods of time early in the spring then remain in the webs during adverse weather. The browntails' early spring habits cause considerable damage to developing leaves and shoots and allow the larvae to grow to sizes not suitable for control with B.t. products before there is sufficient leaf surface area to use as a target. Despite the high rates of B.t. applied the late larvae that were sprayed in 1992 most probably received a sub-lethal dose (as indicated by the very sluggish movements of the larvae following the application).

A compounding factor in the lack of success of this project is that weather conditions are not conducive to aerial spray applications in the spring on the coast. Strong breezes, caused by the cool ocean and warming air, fog and normal unsettled spring conditions combine to leave few days when spray can be aerially applied. These conditions may delay applications and limit insect feeding activity following an application.

Sampling in the spring to get a true representation of the browntail population levels has been difficult due to the their gregarious habits and continual movement to and from feeding areas. Post to pre spray comparisons were not successful in either spring trial because weather delays and the slow mode of action of the B.t. Sampling was based on the health of individually marked overwintering webs and it was assumed the larvae would remain near their webs until post spray samples were taken. Unfortunately the high larval populations rapidly defoliated their host plants

close to the overwintering webs and then moved to foliated sections of the host tree where members of several overwintering webs concentrated in large communal webs making it impossible to determine browntail mortality based on web counts. A very fast acting chemical could be sampled with the techniques used here, but any delay of mortality will allow the time for the movement of the larvae and result in the loss of the pre spray sample.

Future trials of any pesticides that do not cause very rapid mortality of the browntail should involve a random sample of the population after exposure (treatment) to be reared in the laboratory with a control group to eliminate the dispersal problems experienced in these trials.

Summary

Browntail moth populations reached levels high enough to warrant island wide control efforts on Little Diamond Island, Portland, Maine in 1992. One late season and two spring aerial B.t. trials were run in 1992 and 1993. None of the trials succeeded in providing an acceptable measure of control. At this time no further trials are planned using aerially applied B.t. Weather, browntail feeding habits and host phenology do not provide conditions conducive to this control strategy. Ground application of B.t. or a different pesticide may provide acceptable control of the browntail moth.

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